Multimodal Visualizations for Pre-Operative Neurosurgical Planning

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Abstract: In the living brain, vital structures include cortical areas as well as neuronal pathways connecting these. If pathologies, for example a tumor are present and derogate essential functionalities, neurosurgical treatment is needed. Neurosurgeries are tailored to the patient-specific anatomy and pathology: Within an individual pre-operative planning phase the most adequate access path to a lesion is defined. This is mandatory with respect to deep-seated structures or lesions close to essential white matter tracts, such as the corticospinal tract or related functional activation zones. It is crucial to minimize the damage of structures at risk during surgery. The presented work foucuses on developing visualizations for neurosurgical planning and thereby supporting the surgeon in answering primary clinical questions such as: What is the relation between the lesion, functional areas and white matter tracts? and How can the lesion be accessed most safely? Therefore, the following challenges are considered in the presented work: Visualization of multimodal data, identification of risk-structures, path-specific visualizations as well as path evaluation.

With Cavity Slicing we introduce an innovative exploration method for multimodal data inspired by focus-context rendering. A user-defined cut-out geometry is applied to an anatomical volume and reveals structures of interest within their surrounding tissue. Potential adaption of the slicing include changes of the cutting geometry itself or the position, that is either view-dependent or view-independent. Considering the slicing geometry as the extent of the access path, properties of the brain are directly related to the intervention and risk-structures can be identified and examined.

Vital properties of the brain and potential risk-structures are neuronal pathways and activation areas, located on the cortex. To define pathways connecting certain cortical areas, we apply a fiber filtering approach. The resulting neural connections are represented by an encompassing hull to avoid visual cluttering and differentiate between tracts.

The presented approach includes an enhanced visual representation of the access path, to provide a better understanding of its attributes such as length and spatial arrangement. Furthermore, an intuitive evaluation of potential access paths in terms of incision point and distance to risk-structures is introduced. Computer graphics techniques are used to encode the distance of structures at risk, neuronal pathways for example, to the access path.

The presented work is based on the IEEE Visualization Contest 2010 submission from the University of Koblenz.